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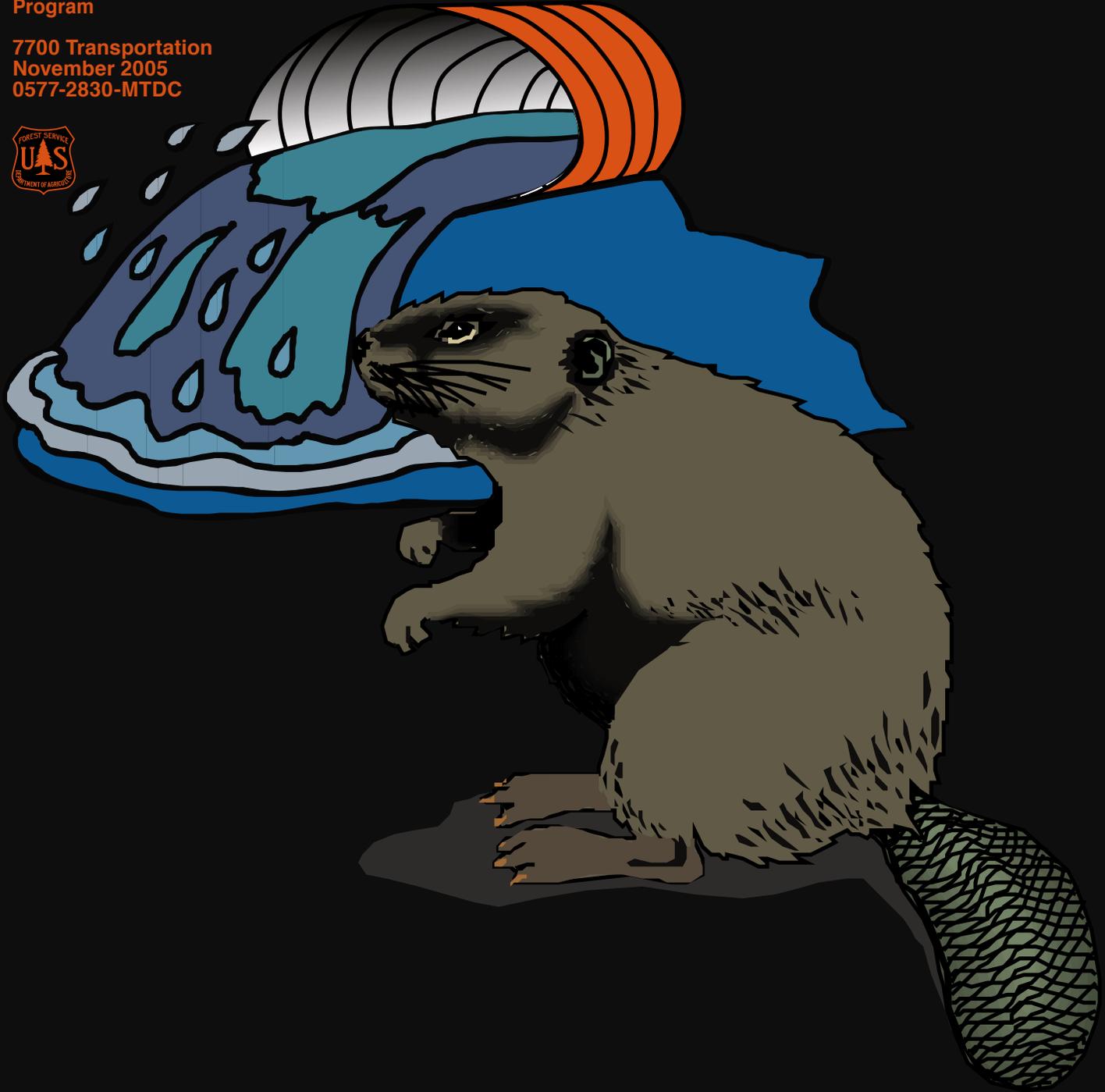
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How To Keep Beavers from Plugging Culverts



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Contents

Introduction _____	1	Trapping _____	19
Beavers _____	2	Forest Service Experience _____	19
Resolving Culvert Problems Caused by Beavers _____	3	Shooting _____	20
Devices that Prevent Beavers from Damming Culverts _____	5	Devices To Frighten Beavers _____	21
Culvert Guards or Grills _____	5	Forest Service Experience _____	21
Culvert Fences _____	6	Electric Barriers _____	22
Wire Mesh Culvert Extensions _____	8	Forest Service Experience _____	22
Enlarged Cylinders _____	9	Repellants _____	23
Waterflow Devices _____	10	Fences _____	24
Corrugated or Perforated Tubing _____	10	Conclusions _____	25
Clemson Beaver Pond Levelers _____	12	Appendix—The Clemson Beaver Pond Leveler _____	26
T-Culverts _____	14		
Culvert Blocks _____	15		
Three-Log Drains _____	16		
Comparing the Different Methods of Protecting Culverts _____	18		



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Introduction

Beaver populations increased dramatically during the last half century. Beavers and beaver dams now are found on rivers, streams, and creeks across the country. Although beavers dam streams for their own benefit, the ponds create habitats for birds, fish, and other wildlife.

Unfortunately, as road engineers and maintenance crews know, beavers also plug culverts. When culverts are plugged (figure 1), roads can be washed away by flooding. Removing the beavers' dams usually requires heavy equipment, which is costly.

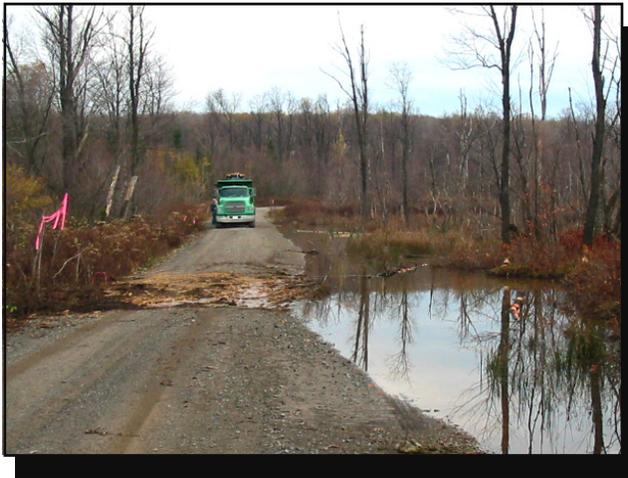


Figure 1—A culvert blocked by a beaver dam on the Allegheny National Forest.

The U.S. Department of Agriculture (USDA) Forest Service Missoula Technology and Development Center (MTDC) was asked to investigate methods to solve the problem of beavers damming culverts. Road maintenance costs could be reduced if beavers could be prevented from damming culverts. Ideally, these methods would maintain beaver populations and associated wildlife.

MTDC asked Forest Service personnel about the strategies they had used to deal with problems caused by beavers. Additionally, MTDC requested the help of USDA Animal and Plant Health Inspection Service, National Wildlife Research Center (NWRC) beaver experts, and their colleagues. The NWRC presented a full report to MTDC. That report can be obtained from Andy Trent at MTDC.



This report includes the methods described by the NWRC experts followed by discussion of the experiences of the 50 Forest Service employees who responded. In some cases, no respondents had tried methods described by the NWRC. No *silver bullet* approach will take care of all beaver problems. But this report will describe a number of methods that can be used, depending on the particular situation.

Highlights...

- As beaver populations have recovered from unregulated trapping during the 19th century, beavers have been causing problems by damming culverts.
- The rapid flow of water through the culverts and noise of running water trigger the beaver's instinct to build a dam.
- If the speed of flow and the noise of running water can be reduced, beavers may leave culverts alone.
- Often, the best solution is to replace the culvert with one that is oversized or to move it to a more suitable location. Either choice is expensive.
- When existing culverts can't be replaced or relocated, options include:
 - Installing devices that keep beavers from damming culverts
 - Installing waterflow devices that control the speed and noise of the water
 - Using devices to frighten the beavers (short-term solution)
 - Trapping or shooting the beavers (they could be replaced by others living nearby)
 - Fencing the area to keep beavers out



Beavers

Beavers (*Castor canadensis*) are the largest native rodents in North America (figure 2). They are found throughout North America, except for the Arctic tundra, and desert Southwest. Beavers can live almost anywhere with year-round water and winter forage. Trapping during the late 1800s significantly reduced beaver numbers. Although an estimated 60 million beavers lived in the United States before European settlement, they had been nearly exterminated by 1900. During the 20th century, beaver populations rebounded, primarily because of restrictions on trapping and translocation programs conducted by wildlife agencies. Most adult beavers weigh between 35 and 50 pounds and are about 3 feet long from head to tail. Some beavers weigh more than 100 pounds.



Figure 2—The beaver is a stocky animal well adapted for life in the water. They have large front teeth (incisors), webbed rear feet, and a broad flat tail.

Given a water source and a supply of food (trees and brush), beavers can create suitable habitats for themselves. Beavers frequently build dams to modify their environment. In addition, they mound sticks and mud to build lodges (figure 3) and burrow into banks to construct underground dens. In colder climates, beavers collect and store plants, forming food caches for the winter. This behavior is less common in warmer climates.

Beaver dams and the ponds behind them reduce erosion while increasing vegetation diversity and edge habitat, where water meets the land. Other wildlife species generally benefit, but beavers can be destructive. Reduced waterflow can harm some wildlife. High beaver populations also can harm native plant communities. Extensive foraging by beavers can destroy plant restoration projects. Beavers have severely hampered efforts to establish vegetation for improved salmon habitat in the Pacific Northwest.

Beavers generally are active for about 12 hours each night, but may be active during the day. Beavers are regarded as monogamous, forming family groups that include an adult male and female, along with their offspring. Emerging evidence suggests that beavers living where winter food is not limited, in the South for instance, may have larger colonies with several reproductively active females. Females give birth to two to four kits each spring. The kits remain with the family for a couple of years before dispersing to establish a new territory.

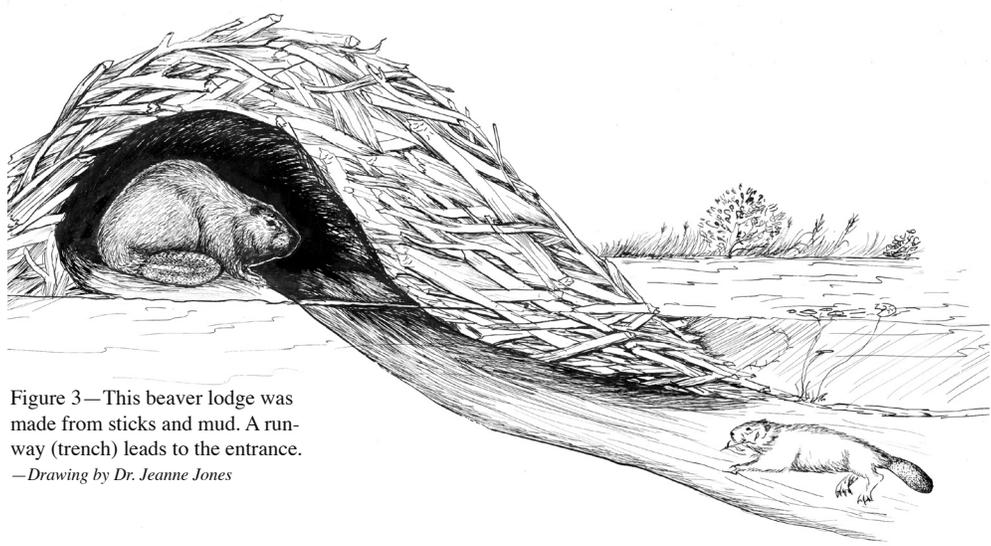


Figure 3—This beaver lodge was made from sticks and mud. A runway (trench) leads to the entrance.
—Drawing by Dr. Jeanne Jones



Resolving Culvert Problems Caused by Beavers

Culverts can create the ideal conditions for beavers (figure 4). Beavers instinctively build a dam when they hear the noise of water channeled through a culvert. Culverts usually have hardened embankments that give beavers a foundation for their dams. Riparian areas nearby often provide habitat and a food source for the beaver.

Some national forests have demolished beaver dams in hopes that the beavers would leave the area. Dams can be demolished by hand, with backhoes or other types of equipment, or with explosives (not generally recommended). While demolition may work occasionally, beavers usually rebuild or repair the dam within days, especially in areas with good beaver habitat.

This report describes ways to manage beavers and existing culverts. In many cases, the ideal solution would be to replace or relocate the culverts to more suitable locations or conditions. Doing so can be very costly. New or replacement culverts should be designed to prevent beavers from damming them. Oversized culverts should be used to reduce the speed of flow through the culverts, decreasing the likelihood that beavers will want to dam them. Oversized culverts also make fish passage easier. Some people have had good success with steel culverts with flared ends or rectangular concrete culverts.

If replacing culverts is not an option, several methods of controlling beavers around existing culverts include:



Figure 4—Most culverts create ideal locations for beavers to construct their dams.



- Installing devices that keep beavers from damming culverts
- Installing devices that reduce the speed of waterflow at the culvert's entrance or exit
- Trapping or shooting beavers
- Using devices to frighten beavers
- Using repellants
- Installing fencing

Common names of devices used to control beavers (beaver bafflers, beaver deceivers, or beaver relievers) have not been used in this report because these names are not used consistently across the country. One person's deceiver is another's reliever, and so forth.



Devices that Prevent Beavers from Damming Culverts

Various devices can be used to prevent beavers from entering and damming culverts. Some of these devices prevent the beaver from damming the end of the culvert. Others keep the beaver from building a dam inside the culvert. Maintenance is much easier if beavers build their dam outside the culvert rather than inside.

Culvert Guards or Grills

These devices prevent beavers from constructing dams inside culverts. They do not prevent beavers from damming a culvert. They should always be installed on the upstream end of a culvert; otherwise, beavers are likely to fill the culvert with debris, using the device to help them start their dam. Wire mesh mounted to a metal frame can be installed across the front of a culvert.

A rod grill can be constructed by welding $\frac{1}{2}$ - to $\frac{3}{4}$ -inch steel rods (rebar) to a plate at 6-inch intervals. The vertical rods are driven into the streambed. Pressure from the current will hold them in place. A slightly more complicated design uses a plate as wide as the culvert that is welded between two posts or angle iron mounted on either side of the culvert. The rods are not welded to the plate, but are inserted through holes drilled every 6 inches (figure 5). This approach allows individual rods to be pulled when the grate is cleaned. Once most of the debris in front of the grate has been removed, the rods can be lifted, enabling smaller material and mud to wash through the culvert.

Another design uses rods welded about every 6 inches to links of chains fastened to the upper ridge of the culvert and stretched in both directions along its outside perimeter (figure 6). The rods and chains continue for several feet or more on the ground in front of the culvert. A collecting chain fastened to the bottom rod is looped back above the culvert. When debris plugs the culvert, this chain is hooked to a vehicle so the whole contraption, along with the debris that has collected, can be pulled back over the culvert.

Forest Service Experience—The Eastern and Alaska Regions have used culvert guards effectively. Some employees have built grates of rebar or tubing that mount on the culvert. Others have drilled holes through the end of the



Figure 5—This beaver guard is constructed by inserting steel rods through a frame mounted on the front of a culvert.



Figure 6—This beaver guard has chains that allow the guard and any debris that collects on it to be pulled up over the culvert.

culvert that allow rebar to slide through. This method allows the rods to be removed easily for maintenance. The problem with this approach is that the end of the culvert breaks down over time. Everyone who has used culvert guards says that although the guards do not prevent beavers from building dams, they do allow dams to be removed more easily.

Culvert Fences

Many designs have been prepared for installing fencing in front of culverts (figures 7 and 8). Some designs are called *deep water fences* or *beaver deceivers*. No matter what the fences are called, they are designed to keep beavers away from culverts. Waterflow and its associated noise are directed away from a culvert, reducing the cues that cause beavers to build dams. If beavers do attempt to halt waterflow, the area they must block is considerably larger. The deeper the water,

the more difficult it is for beaver to pile up enough materials to restrict waterflow.

Fences can be constructed from a variety of materials, but 6- by 6-inch reinforced steel mesh held in place with steel posts works well. A variety of sizes and configurations (rectangular, triangular, trapezoidal) have been proposed for beaver fences. Site condition plays an important role in fence designs. The farther the fence perimeter is from the culvert, the more effective the fence is likely to be. Sites with rapid

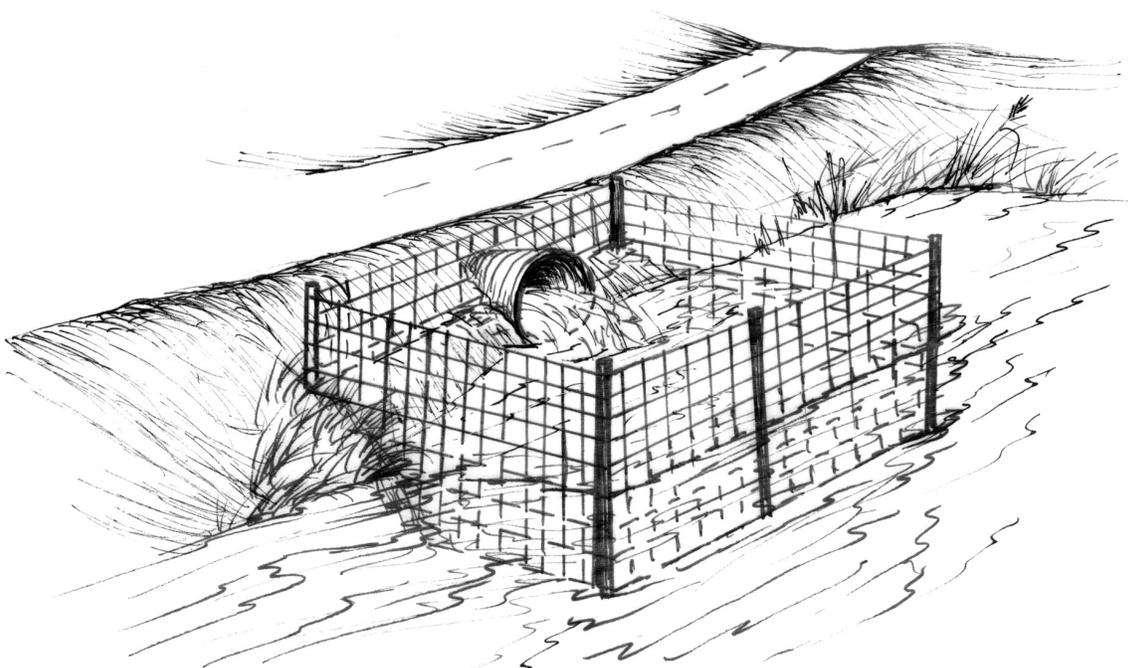


Figure 7—A fence built from panels of metal mesh can keep beavers from reaching a culvert.—Drawing by Dr. Jeanne Jones



Figure 8—A rounded fence can help keep beavers from damming a culvert.

waterflow may require larger enclosures. Generally, designs that fence off an area 10 to 20 feet on each side of the culvert are adequate. Make sure that the fence blocks access from the shore and across the top of the culvert.

The fence's bottom must be tight against the stream or pond bottom. Burying the fence can help prevent beavers from digging underneath. A floor, made from the same mesh, can be added where the bottom is uneven or if the substrate is unstable. Beavers do not climb, so extending the wire a couple feet above the high water mark is adequate. Wire mesh across the top of the enclosure may be beneficial. Some designs incorporate a deck across the top, allowing

humans to access the impounded water, while blocking beavers.

A device can be installed to allow waterflow into the fenced area. If beavers block the fence, the device can serve as an emergency spillway during high water. Additional fenced areas established farther from the culvert, perhaps in deeper water, can be connected to the first fence by laying pipe between them (figure 9). If shallow water or other conditions prevent fences from being built close to culverts, fences built farther out can serve as an intake point for a modified waterflow device. The culvert can be extended to the fenced area or connected with a pipe. The pipe would need to fit snugly inside the culvert and be of similar size to pass the desired waterflow.

Forest Service Experience—Fencing culverts is the most widespread method Forest Service personnel have used to keep beavers from damming culverts. Respondents said that culvert fences have been used in the Northern, Rocky Mountain, Intermountain, Pacific Southwest, Pacific Northwest, Southern, and Eastern Regions. Almost everyone had some success with fencing, but respondents pointed out some shortfalls. In some cases, the beavers did not build dams. In other cases, they built dams on the fence, which required periodic maintenance. It is especially important to extend the fence below the ground level or the beavers will dig under it. In northern climates, ice flow sometimes destroys the installations.

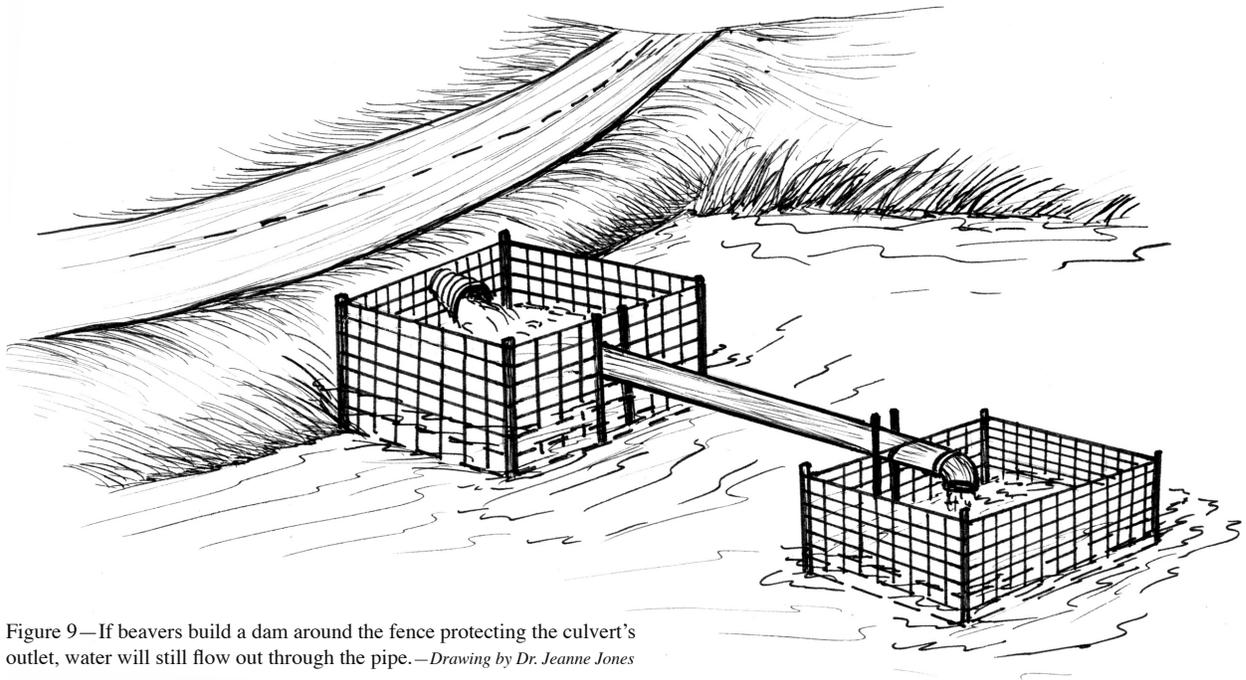


Figure 9—If beavers build a dam around the fence protecting the culvert's outlet, water will still flow out through the pipe.—Drawing by Dr. Jeanne Jones



Wire Mesh Culvert Extensions

This method extends the culvert with heavy-gauge wire mesh that would be nearly impossible for the beaver to plug. A form was made from 6-gauge concrete reinforcing mesh panels (8 feet long) covered with galvanized welded wire mesh (14 gauge with a 1-by 2-inch mesh, figure 10). The form was rolled into a cylinder that was held in place with number 3 hog rings. Hog rings also attached the wire mesh to the larger reinforcing mesh. These panels can be transported fairly easily to problem sites and connected to make longer extensions. The wire culvert can be placed in a notch cut in a beaver dam or attached to the opening of a road culvert. If the road culvert is larger than the wire mesh culvert, any remaining opening needs to be covered with additional mesh



Figure 10—The *Beaver Stop* wire mesh culvert extension.—Courtesy of FSI Culvert, Inc.

or beavers will fill the culvert with debris. Normally, at least three sections are connected to form an extension at least 24 feet upstream from the culvert.

More complex models have been proposed. The heavy-gauge wire mesh is rolled into a cylinder to fit the inside diameter of the culvert to be protected. Hog rings hold the shape of the cylinder. The cylinder slides inside the culvert where it forms a tight fit. Afterward, the cylinder is covered with a lighter and smaller mesh wire (1- by 2-inch mesh).

A larger cylinder is formed using heavy-gauge wire mesh around the inner cylinder, with a diameter about 12 to 20 inches larger. Fencing wire or other lightweight wire (9 gauge) strands are tied to the inner cylinder and connected to the outer cylinder so that the inner section forms a central core about 6 to 10 inches from the outer cylinder. The outer cylinder is mounted over the outside of the protected culvert with its ends bent to fit tightly around the culvert. Metal fence posts are driven through or on either side of the outer wire to hold the apparatus in place. Additional sections can be added as necessary.

Forest Service Experience—No respondent had used wire mesh culvert extensions. The Forest Engineering Research Institute of Canada (FERIC, <http://www.ferric.ca/en/>) describes the successful installation of a wire mesh culvert extension in *Preventing Beaver Dams from Blocking Culverts* (M. Partington 2002). That installation cost about \$1,600 Canadian.

Enlarged Cylinders

Enlarged cylinders are similar to the wire mesh culvert extensions, but are much larger. Wire mesh panels used to reinforce concrete, or similar mesh materials, are rolled into cylinders (figure 11). These cylinders are considerably larger



Figure 11—A culvert guard can be constructed by rolling wire mesh panels into cylinders.

than the culvert they protect, perhaps 10 feet in diameter. The longer the cylinder, the better. The intent is to keep beavers as far away from the culvert as possible. Both ends of the cylinder may be closed with mesh panels. The front panel is cut to form a tight fit around the protected culvert.

Metal fence posts may be able to anchor smaller cylinders, but 2- to 4-inch steel pipe may be needed for large cylinders. Wooden posts are not advised for obvious reasons. The area in front of the culvert needs to be dug out as deep as possible before the cylinders are installed. The large mesh cylinder is not covered with smaller mesh, as is the case in some other designs. Larger sticks are caught by the large mesh, but smaller debris washes on through the culvert.

Forest Service Experience—No respondents had used enlarged wire cylinders.



Waterflow Devices

Beavers are particularly adept at manipulating their environment to suit their needs. They instinctively build dams to raise water levels and increase the area covered by water. Beaver ponds provide security for beavers while they move from one feeding site to another and allow them to transport construction materials easily. Although beaver ponds have many desirable features, flooding can be a problem, especially when it affects roads. Often, attempts to lower water levels are futile. When beavers hear running water, they add debris to block the flow. Any opening in a manmade or natural structure that produces the sound, appearance, or feel of escaping water will cause beavers to make repairs. Daily efforts to unclog manmade structures (such as culverts) or to make openings in beaver dams simply inspire beavers to make nightly repairs (figure 12).



Figure 12—Beavers repeatedly repaired this dam that they had built in front of a culvert.

Waterflow devices prevent beavers from perceiving the cues that cause them to build and repair dams. Designs for waterflow devices range from basic to complex. Recommended materials vary from natural components to plastics and metals. Site conditions, available resources, and management objectives will determine which device is best for a given situation. Incorporating the best features from several designs into a custom device that fits your specific conditions may yield the best results.

Certain criteria are important when installing any waterflow device. The water should be at least 3 feet deep at the device's intake. Alternatively, a trench, at least 4 feet deep

and 8 feet wide, can be excavated beneath the intake, or along the entire length of the device's tubing that will be in the pond. The device should be sized to pass the required flow. If the waterflow device can accommodate no more than normal streamflow, short periods of flooding during high streamflow must be acceptable.

Use caution when working around culverts. Generally, it is not wise to constrict waterflow through a road culvert. Install the sizes of culverts needed to handle streamflows, based on engineers' estimates. Culverts need to be inspected regularly and cleared of debris so they will remain open.

It is dangerous to stand in the downstream channel while unblocking a culvert or to crawl inside a culvert while clearing debris. Always check the water levels on the upstream side. High water levels may exert pressure on blockages inside culverts, causing them to give way suddenly when they are disturbed.

Waterflow devices tend to fail because beavers plug the pipes or pull them from the dam whenever they can figure out how to do so. Pipes must be laid securely and fixed in place. The water intake area needs to be protected so beavers can't reach it.

Some users have claimed that waterflow devices do not require maintenance. Perhaps this is true under some circumstances. However, regular inspections and maintenance will reduce potential failures and possible flooding. High-water events can damage the devices.

Devices probably should be checked a couple of times a year, or at least before seasons when high water is expected. Maintenance generally requires removing debris and mud from intake areas, repairing breaks, or reconnecting pipes. If mud or silt has filled in around the intake areas, considerable effort or heavy equipment may be needed to clear the silt so the water can be restored to its original depth. These repairs are much easier during low-water periods, but beavers also have better access to build their dams during those periods.

Corrugated or Perforated Tubing

Corrugated tubing installed through culvert inlets or beaver dams can allow water to flow without creating the cues that cause beavers to make repairs or build dams. Corrugated

plastic tubing can be obtained from most stores that sell construction materials. The appropriate diameter depends on the discharge flow. If the streamflow is known, the proper size can be determined by comparing the streamflow with standard rates of discharge for different diameter tubes (table 1). Several pipes can be used to increase the flow.

Table 1—Approximate water discharge rate for select tubing.

TUBING (whether perforated or not)	
Tube diameter (inches)	Water discharge (gallons/minute)
3	13.5
4	15.3
5	27.4
6	44.9
8	98.7
10	152.6
12	246.8
15	439.8

Perforation varies, but flow can be increased by drilling holes in the tubes. Small cuts made by the manufacturer often clog when silt and algae build up. Drill a 1-inch hole in every other high point of the last 10 feet of corrugated pipe nearest the intake point. The holes will increase the waterflow in deeper water away from the dam where it is less likely to be detected by beaver. These holes also allow air to escape from the corrugations, reducing the tubing's buoyancy and making it easier to anchor in place. Chicken wire or welded wire (2- by 2½-inch mesh or smaller) can be wrapped around the tubes to prevent beavers from damaging them. The wire also adds weight to the tubing, making installation easier. Tubes can be joined using a coupler or by sliding a split tube over adjoining tubes and using wire to bind the split tube. The intake end of the tubing should be covered with welded wire to prevent beavers from inserting sticks or other debris into it.

Installing the tubing is fairly straightforward. If the culvert is relatively small, it is best to use tubing the same size as the culvert. However, culverts generally are larger

than most tubes. A grate mounted on the intake end of the culvert will prevent beavers from plugging the inside of the culvert. The tube is inserted through an opening cut in the grate. The unperforated end of the tube is inserted in the culvert. The perforated end should be held in place with a series of metal posts driven on either side. Wire tied above and below the tube will hold it at the desired depth. Beavers may cover tubes with mud if the tube is lying on the pond's bottom, so it is best to keep the end of the tube off the bottom.

Installing several tubes will increase the potential discharge. If beavers block the culvert, the amount of discharge will be reduced to whatever can pass through the tubes. If that happens, additional smaller culverts or a larger beaver guard can be installed to restore the needed flows.

The techniques for installing tubes through a beaver dam are similar to those for installing tubes through culverts. A notch is cut in the dam. The tube is laid through the notch with the intake end fastened as described before. The outlet end is extended some distance downstream from the front of the dam below the dam's base, reducing the risk that the beaver might plug the outlet or build another dam immediately below the first one. The tubes need to be checked periodically and maintained if necessary. Maintenance usually consists of adjusting the tubes' anchors or posts and raking mud and debris away from the openings in the tubes. The extent and frequency of the maintenance will depend on beaver activity in the area.

Forest Service Experience—Several respondents reported success using the perforated pipe. In the Southwestern Region, perforated pipe was extended about 4 to 5 feet beyond the culvert opening through a beaver dam, allowing water to flow until a road maintenance crew could remove the dam. The pipe prevented the road from being damaged by flooding. The Pacific Northwest Region has used corrugated pipe with 3- to 4-inch holes, with success. The pipe is extended 8 to 10 feet in front of the culvert inlet. The Northern and Rocky Mountain Regions also have had success using this method.

Both regions described removing a dam, laying perforated drain pipe about 4 feet into the culvert, and then extending the pipe 20 to 40 feet on the bottom of the stream. Wire fence panels were fastened to posts about 10 feet from the



culvert and on top of the perforated pipe. This system allows beavers to try to build a dam against the fence panel while water continues to flow through. Maintenance may be needed to clean the perforated pipe or to remove debris from the fence panel, but that maintenance is far easier and less costly than cleaning the culvert. Both regions have had several years of success.

Several other respondents reported trying this method with little success. Beavers plugged the pipe with mud within days or, in one case, beavers used sticks to plug individual holes in the perforated pipe.

Clemson Beaver Pond Levelers

The Clemson Beaver Pond Leveler (figure 13) was designed to keep beavers from detecting where water is escaping by eliminating the sound of rushing water or by moving the sound downstream from the dam site. The leveler's intake device and reducer sleeve slow water movement

through the system (figure 14). The intake device is constructed from 10 feet of 10-inch-diameter schedule 40 polyvinyl chloride (PVC) pipe that has been perforated with 160 evenly dispersed 2- to 2¹/₂-inch holes. The upstream end is capped, while the downstream end is fitted with a reducer sleeve that connects to an 8-inch PVC pipe. Ten times as much water can flow through the perforations as can flow through the 8-inch outlet pipe. The reduced rate of flow reduces the noise as water enters.

The intake pipe is suspended inside a 30-inch-diameter cylinder formed from rolled sheets of 2- by 4-inch galvanized welded wire mesh. The wire cylinder is closed at the capped end of the intake pipe and fitted around the reducer sleeve with wire mesh. The cylinder can be held in place with wire attached to four sides of the pipe and extended out to the cylinder. An alternative but more expensive approach is to insert 3/8- by 30-inch threaded rods through the intake pipe, locking them in place with washers and nuts. Additional washers and nuts placed on either side of the cylinder hold

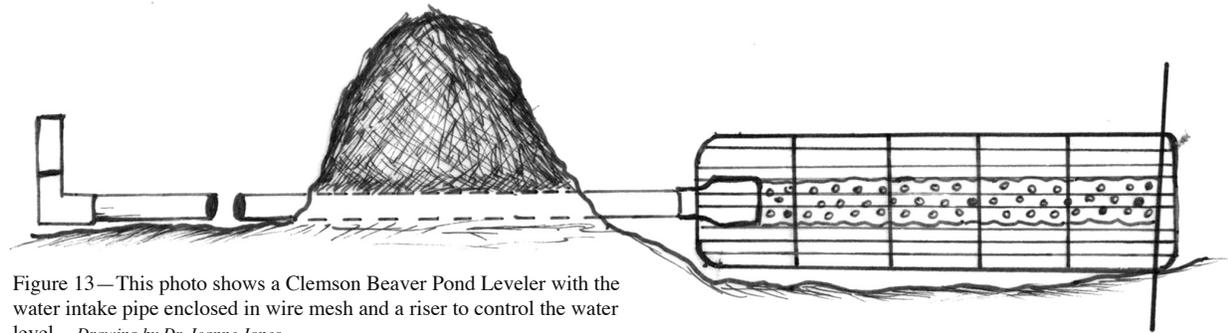


Figure 13—This photo shows a Clemson Beaver Pond Leveler with the water intake pipe enclosed in wire mesh and a riser to control the water level.—Drawing by Dr. Jeanne Jones



Figure 14—The Clemson Beaver Pond Leveler uses a perforated PVC pipe for water intake and a reducer to limit waterflow through the output pipe.

it in place. Two rods adjacent but perpendicular to each other at both ends of the intake device and about every 5 feet along it stabilize the cylinder. The wire cylinder prevents beavers from getting close enough to pile debris on to the perforations. A couple of metal posts, one on either side of the cylinder, are generally adequate to hold the device in place.

Installing the leveler is fairly straightforward. First, open one trough through the dam for each leveler to be installed. The appropriate number of levelers would be the number needed to drain water out of the pond at a rate equal to or faster than the rate at which water flows into the pond. If road culverts are plugged, all debris should be removed from them before the leveler is installed. If beavers return and plug the culvert, waterflow will be restricted to the amount of water that can pass through an 8-inch pipe.

The perforated intake pipe is installed upstream of the dam and oriented parallel to the stream channel, if possible. The intake pipe should be installed so that it will be submerged to the greatest extent possible when the pond is at its lowest level. The outflow end of the intake device needs to be slightly lower than the capped end and should be no closer than 5 to 10 feet from the dam or culvert. Additional 8-inch pipe can be added to move the intake pipe farther away from the dam, if necessary. An elbow can be inserted in the outlet pipe if the dam or culvert was constructed at a bend in the stream.

The outlet pipe is laid through the trough in the dam so that it slants downward slightly from the reducer sleeve. The outlet end should extend at least 20 feet beyond the dam or completely through a culvert. It is best if the end of the outlet is underwater.

A T-joint at the terminal end of the outlet pipe allows the water level of the pond to be manipulated. The T-joint is positioned so that a standpipe on one side of the T (the riser) can point upward. A plug is inserted in the bottom side of the T. When the bottom of the T-joint is open, the pond will drain. When the bottom of the T-joint is plugged, water will rise to the height of the riser. An alternative is to use an elbow with a standpipe. When the standpipe is laid down, the pond will drain. When the standpipe is turned upright, the pond will drain to the height of the standpipe. The standpipe can be wired to a metal post to keep it in place.

Forest Service Experience—The Clemson Beaver Pond Leveler has been used successfully in the Southern and Eastern Regions on the Superior, Wayne, Francis Marion and Sumter, and Nantahala National Forests, among others.

T-Culverts

T-Culverts can prevent beavers from plugging road culverts (figure 15). The following prerequisites should be considered when determining whether these devices might be effective at a particular site:

- Streamflow needs to be moderate.
- Culverts should be 3 feet in diameter or smaller.
- The normal flow through the culvert should fill about one-fourth of the culvert's diameter.
- Both ends of the T-culvert need to rest in relatively still water, about 4 to 6 feet deep, for best results.
- The substrate should be solid, to prevent material from sloughing into the culvert and filling it. The substrate is particularly important if a trench is dug to install the T-culvert.

T-culverts can be constructed from any metal culvert by cutting a hole in the side to install a smaller connecting culvert. The larger culvert is used for the T. A 4-foot-diameter T-culvert is recommended for road culverts between 6 and 18 inches in diameter. Larger road culverts, from 18 inches to 3 feet in diameter, require a T-culvert that is at least 5 to

6 feet in diameter. These large inlets enable water to enter at a low velocity, which is less noticeable to beaver. The T-culvert should be 8 to 12 feet long—longer is better.

A smaller culvert connects the T-culvert to the road culvert. The connecting culvert is inserted into a hole cut to fit about one-third the distance from the bottom of the T-culvert. When the T-culvert is set in place, this hole must be below the road culvert, so the connecting culvert angles upward. The connecting culvert should be slightly smaller than the road culvert so it can slide about 6 inches into the road culvert at a slight upward angle. If the connecting culvert is much smaller than the road culvert, waterflow will be restricted.

The length of the connecting culvert depends on site conditions, but 6 to 8 feet usually is adequate. The ends of the T-culvert are covered with number 6-gauge reinforcing wire mesh. Small holes drilled around the perimeter permit the mesh to be wired into place or the protruding ends of the mesh can be threaded through the holes and bent over.

Forest Service Experience—No respondents had used this method.

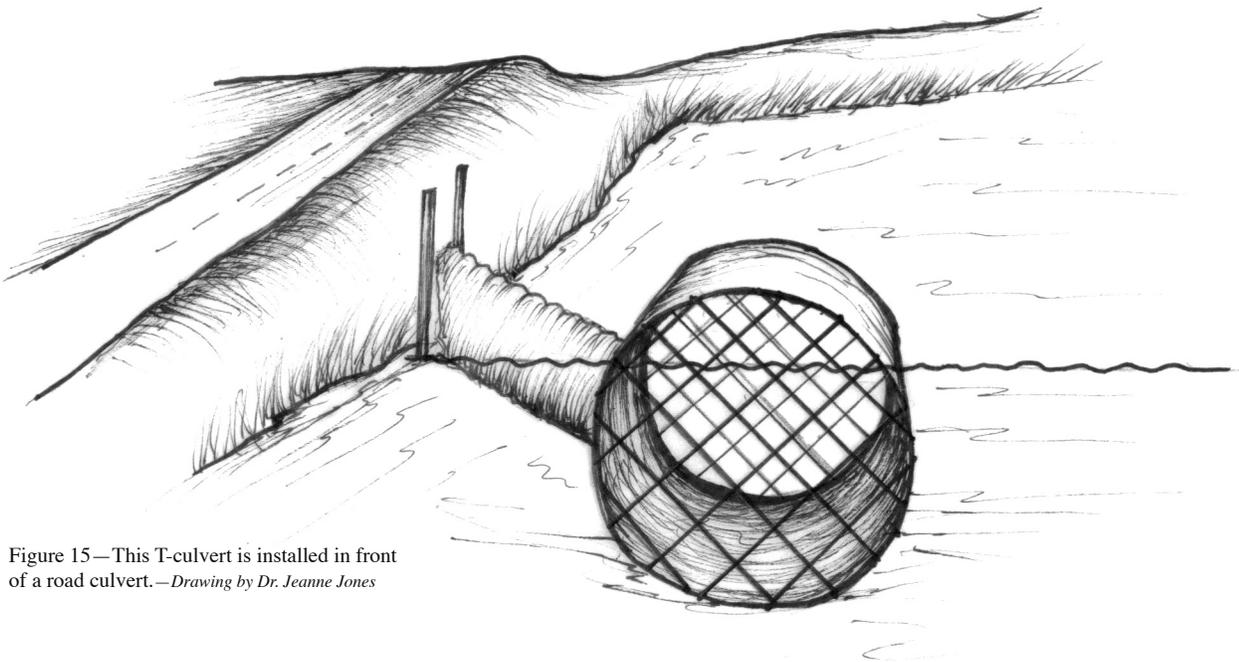


Figure 15—This T-culvert is installed in front of a road culvert.—Drawing by Dr. Jeanne Jones

Culvert Blocks

Another approach is to slow waterflow through the culvert. The culvert outlet is blocked with boards, plywood, or metal sheeting across the culvert opening. Wire mesh can be added for support if necessary. Water is allowed to seep through cracks in the boards or through small holes drilled in the covering. The concept is to limit the sound of running water, reducing the likelihood that beavers will dam the culvert. Such an approach can be used only during low water and the blockage must be removed before high water is antici-

pated. Although this approach might be feasible in some situations, it would require close monitoring.

Forest Service Experience—No respondents used this exact method. However, some persons have plugged culverts themselves during low water to keep beavers from damming them. A low-water ford can be created in the road by hardening a dip near the culvert, allowing water to flow across the road. The culvert is unplugged during high water. This method is safe for low-volume roads.



Three-Log Drains

This simple drain is made from three or more hardwood logs. Beavers rarely chew through hardwood logs (such as oak logs) when they are underwater. The structure is placed perpendicularly through the dam as described for the pipe drain. Two logs are laid on top of a board or sheet of iron with their upstream ends slightly apart. A third log is placed on top. Water runs through the funnel formed by the logs and seeps along their edges.

A similar approach might be used to prevent beavers from damming a stream. A blind drain constructed from stones, logs, tiling, perforated drain pipe, or similar materials laid along a streambed will allow water to flow beneath a dam. If beavers build a dam, the streambed below the dam will remain permeable, preventing water from collecting behind it. Generally, beavers will move to a more suitable site.

Another adaptation of the three-log drain reduces opportunities for beavers to plug openings created by uneven logs

(figure 16). Sheet metal (30 inches wide and 6 to 8 feet long) is laid along the bottom of an opening cut through the dam. Two green or waterlogged poles, 6 to 9 inches in diameter and 10 to 16 feet long, are placed on top of the sheet metal. The upstream end of these logs needs to be at least a foot lower than the downstream end. Green sticks (1 to 2 inches in diameter) are placed across these logs to support a third log, which is laid across the sticks and centered above the bottom logs.

Sheet metal, about the size of the sheet placed on the bottom, is wrapped over the top log and along the sides of both bottom logs. The sheet metal is nailed along the sides of both bottom logs and the top of the top log to hold the drain together. The intake end of the drain can be anchored by driving a forked stick into the pond bottom with the fork hooking the top log to hold it down.

Forest Service Experience—No respondent had used this method.

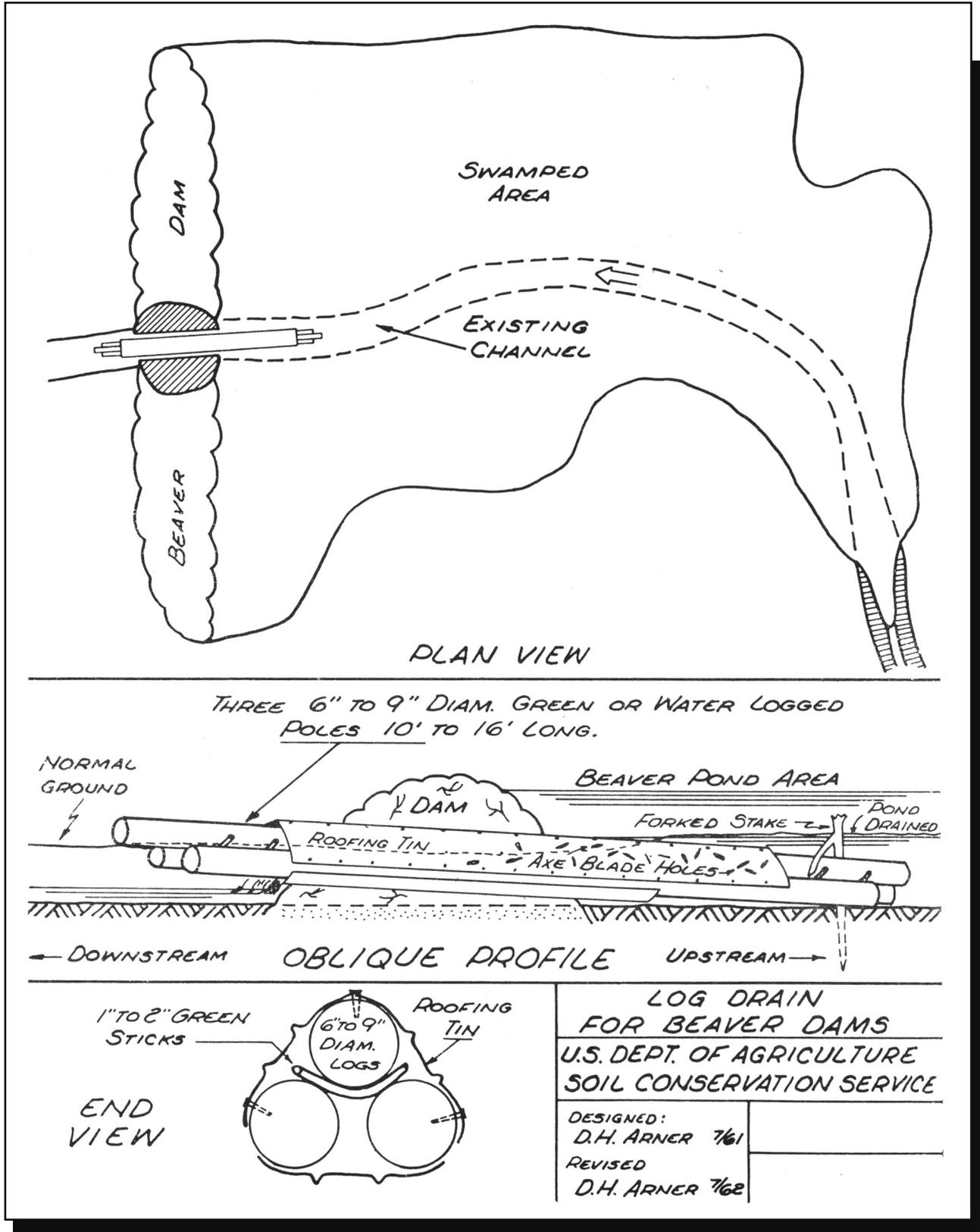


Figure 16—This drawing shows a modified three-log drain could be used to partially drain ponds impounded by beavers.



Comparing the Different Methods of Protecting Culverts

Table 2 shows the advantages and disadvantages of five methods to prevent beavers from plugging culverts.

Table 2—The advantages and disadvantages of five methods to prevent beavers from plugging culverts.

DRAIN PIPES

Advantages: Inexpensive; maintain a set water level.

Disadvantages: Require installation; regular cleaning and maintenance; success varies.

CULVERT PIPES

Advantages: Inexpensive; easy to construct and install.

Disadvantages: Must be set deep enough to keep the intake fully submerged; require regular maintenance; reduce waterflow through the culvert; may hinder fish passage; success varies.

CLEMSON BEAVER POND LEVELERS

Advantages: Low maintenance; maintain set water levels; several levelers can be used in heavy flow areas.

Disadvantages: High initial investment to build and install; intake must be fully submerged to work optimally; single sets are inadequate to handle high volumes or fast flowing water; levelers may reduce waterflow and hinder fish passage.

CULVERT GUARDS

Advantages: Inexpensive; easy to install; success is good when the guards are cleaned regularly.

Disadvantages: Require frequent cleaning; may reduce the culvert's discharge capacity; susceptible to ice damage; may block fish passage.

CULVERT FENCES

Advantages: Keep culverts clear; allow high-waterflows to spill over any blockage and drain through the culvert; maintain constant water level; can be regulated when fences are combined with pipes.

Disadvantages: Expensive, especially if an extended area needs to be enclosed; require regular maintenance; may create an impoundment that affects roads or railroad grades; beavers may build dams high enough to flood the road; fences may reduce waterflow and block fish passage.





Trapping

Trapping can be an effective, practical, and environmentally safe method to trap or remove beavers from areas where they are causing problems. The objectives of the trapping program and the trapper's experience generally determine which types of traps are used. Several factors that need to be considered when you are developing a trapping program include:

- The behavioral and biological characteristics of the target animal
- Access to the target site
- The experience and skill of the trapper
- Nontarget animals in the vicinity
- Cost effectiveness of trapping
- State and Federal laws and regulations
- Other site-specific considerations

Trap-and-release programs can be effective when specific beavers need to be relocated. Release sites should be identified before beavers are captured to prevent releasing animals in areas without appropriate resources or where other beavers already have established territories.

Check local regulations before releasing animals to new sites. State and Federal laws and regulations govern trapping and the treatment and movement of wildlife. Generally, the State Department of Wildlife is the place to contact for information and guidance on trapping regulations.

Most traps pose a minimum danger to humans. However, exercise special caution if children may encounter trap sets. Trapped animals can become agitated. Depending on their size, beavers can be dangerous. Trappers need to exercise caution to avoid injuries while setting some types of traps (such as body-grip and foot-hold traps) and when handling captured animals.

The tech tip, *Using Traps and Snares to Capture Beavers* (0577-2344-MTDC, <http://www.fs.fed.us/eng/t-d.php>) describes various types of traps and some of the techniques used to set them.

Forest Service Experience

Forest Service employees have had mixed results with trapping. Many respondents said that after they tried a variety of nonlethal methods without success, trapping was successful. Some described trapping as a good short-term solution, but said that repeated trapping may be necessary if the site is good beaver habitat. Others thought trapping was not cost effective, because beavers returned to the site and it was difficult to trap entire families. Some respondents felt that relocating beavers is not effective because it just transfers the problem to another site.



Shooting

Spotlighting beavers and shooting them at night may take time, but this technique can be effective. Shotguns (12 gauge) loaded with BB or No. 4 buckshot or small-caliber rifles (.22, .22 magnum, .222 and similar calibers) are used. The shooter sits quietly behind a breach or break at

a dam with the best time period being 1 hour before dark. Check with the State Department of Wildlife before using this approach. Generally, shooting is legal only when State authorities do the shooting or issue a permit to do so.



Devices To Frighten Beavers

Animals generally avoid areas that appear threatening. In remote areas, beavers may be hard to see unless noise and movement are kept to a minimum, but beavers in urban areas may frequent lakes even when people are active along the shore. Visual displays or noises that alarm the animal will discourage its visits. Although animals are generally wary of unfamiliar sounds or sights, they become less wary with time unless the noise or vision is paired with negative reinforcement. Most devices used to frighten beavers (such as artificial lights, propane cannons, or cracker shells) rarely work for more than a few days or a week.

The possibility that wildlife will become accustomed to devices intended to frighten them can be minimized by installing or operating the devices only when they are needed the most. It is important to begin using these devices immediately after the onset of damage. Established movements and behaviors are much more difficult to disrupt than behaviors that are just forming. Devices that operate sporadically or are activated by an animal's presence are more effective than permanent or routine displays.

Visual displays combined with noisemakers generally are more effective than either technique would be if implemented alone. For example, sirens and strobe lights activated at irregular intervals are likely to be more effective than a constant visual display or loud noises emitted at fixed intervals.

Supplementing these techniques with other measures occasionally can increase their effectiveness. For example, beavers will grow accustomed to noise from a radio next to a break in a dam and will ignore it over time, but if someone occasionally jumps out from behind the dam when a beaver

approaches, the radio will do a better job of frightening the beaver.

Several commercial devices can be used to frighten beavers. When these devices are combined with homemade devices, endless combinations are possible. One such device can be created by attaching a *Critter Gitter* (AMTEK, San Diego, CA) on each side of a 4- by 4-inch post that is 12 inches long. The Critter Gitters are attached a couple of inches from the bottom of the post and a flashing light (Enhancer Model EH/ST-1) is attached just above each Critter Gitter. A 2-inch hole bored through the core of the post allows the device to be installed over a metal T-post. The device is then secured to a flotation platform that keeps the motion detectors a few centimeters above the water level.

Trials showed that this device did deter beavers, but not for extended periods. Anecdotal evidence suggests that the device may discourage beavers from repairing dams for a few days if it is installed in a stream channel after a dam has been breached. Those few days might allow the pond to drain temporarily.

Forest Service Experience

Several respondents said they had tried using a white flag attached to a post near the entrance to a culvert or a white bed sheet stretched across the stream channel at the entrance of the culvert. One respondent had success with this method. Another respondent placed a white flag at a culvert entrance after demolishing a beaver dam. The dam was rebuilt within weeks. The second time the dam was demolished, the road maintenance crew found the white flag inside the dam.



Electric Barriers

Electric fence material can be used to shock beavers approaching culverts. One approach used a device that created a mild electric current between electrodes placed in the water when it was activated by movement on the water's surface. When this device was installed properly, it created an electric field in front of a culvert, discouraging beavers from entering the area.

Another approach incorporated a series of wire loops that dangled from a wire electrified with a fence energizer (figure 17). Any animal that touched these loops received a shock. Although these devices can deter beaver activity, they



Figure 17—The Beaverhead-Deerlodge National Forest has used electric fences to frighten beaver.

should be used with extreme caution. The combination of water and electricity could endanger people as well as wildlife. Moving one electrode out of the water could increase the potential hazard. Changing water levels may submerge wires that were intended to dangle above the water.

Although these devices may be applied safely under certain conditions, the potential risks should be considered thoroughly before they are used.

Forest Service Experience

Several respondents said they had used electric fences or hot wires near culvert openings successfully, although one respondent was concerned the device could shock someone. Another problem for that respondent was vandalism of the charger.

Bob Duhamel, who works for the Beaverhead-Deerlodge National Forest used the dangling electrode technique successfully. First, he strings a strand of electric fence wire across the channel about 18 inches above the water's surface in front of the culvert or bridge. Then he uses alligator clips to attach strands of wire with loops at one end. These loops are placed 2 to 3 inches apart and 2 inches above the water. The installation is left in place for about 7 to 10 days. The cost of such an installation is about \$320. It can be reused indefinitely.



Repellants

Repellants are not effective in reducing culvert problems, but may be used to protect riparian areas.

Effective repellants render a plant less attractive to foraging animals. The likelihood that a particular plant will be eaten depends on its own palatability and the availability and desirability of alternative foods. Although beavers tend to avoid plants treated with predator odors, during studies beavers have damaged some of the treated trees.

Beavers readily gnawed through trees treated with deer repellants (Deer Away—Big Game Repellent Powder, Thiuram, and Ro-Pel; NWRC unpublished data). Beaver also chewed branches treated with 100 times the recommended concentration of hot sauce (capsaicin). These studies suggest that the usefulness of commonly available repellants is probably limited.

Chemical repellants did reduce damage when they were applied directly to foliage consumed by beavers. Beavers clipped substantially fewer cottonwood and willow seedlings treated with Deer Away—Big Game Repellent Powder and Plantskydd than they untreated seedlings. These products are among the most effective repellants to reduce deer browsing. These products are not registered for beaver. Future label restrictions may restrict the application of chemical repellants in riparian zones.

Textural repellants (for instance, paint with sand) may offer an alternative. During tests, cottonwood stems that were painted with a textural repellant were damaged less than stems that were not. A few treated trees were cut and others were stripped of bark, but untreated stems or stems painted with untreated paint were damaged severely during this 2-

week trial. Eight of ten beavers completely avoided stems treated with 30-millimeter sand, and gnawing by the other two beavers was very limited. Painting cottonwood stems in this study did not adversely affect the vigor of the stems. Buds sprouted through the paint and new foliage appeared.

Another approach to reducing damage is to convince beavers that unoccupied sites are occupied. During tests, unoccupied sites treated with a mixture of beaver castoreum anal gland secretion were colonized less often than untreated sites. This study indicated that dispersing beaver probably avoid areas with odors indicating they are occupied. However, the feasibility of using such an approach in the field is largely unknown. No product on the market is effective in deterring beaver from settling unoccupied sites. Beavers did not reduce their use of treated areas during experiments with deer repellants.

Although chemical repellants may deter beavers from clipping seedlings and textural repellants may reduce gnawing, site considerations will determine whether these techniques can be used. Plants such as willow that are preferred by beavers are more difficult to protect than plants that are not preferred, such as cascara.

After certain plants have been treated, an animal's foraging choices will depend on the size of the area being protected and the percentage of plants that have been treated relative to all the plants in the beaver's territory. Beavers in sparsely occupied wetlands can expand their territory, but beavers in densely populated areas or in areas with drier climates may not have that option. Competition with other beavers may cause beavers to be less selective in their choice of foods, rendering repellants less effective.



Fences

Fences that could exclude beavers from large areas generally are cost prohibitive. Fences do not need to be high (just 24 to 30 inches), because beavers do not jump or climb well. Beavers will dig or crawl through openings, so the bottoms of fences should be tight against the ground or buried a few inches. Woven wire (4 by 4 inches) will deter beaver, but heavier gauge wire may be needed to protect a highly desirable resource. A 3-foot-high chain link fence (woodland-green, vinyl coated, 2-inch mesh, 0.095-inch core, 9 gauge) kept beavers from harming vegetation in a park. Similar fencing materials or rocks laid along banks can prevent beavers from undermining banks. Generally, a

fence that crosses a small stream and extends 500 feet on either side will stop beavers from traveling along the stream.

Barriers can protect individual trees. Barriers do not have to be more than 30 inches high. Smooth surfaces work best, because if beavers can grasp the barrier's lips or flaps, they may pull or chew on them until they get to the tree.

The best type of barrier depends on the desirability of the protected forage and the availability of alternative foods.

Chicken wire and plastic tree wraps may deter beavers, but beavers can chew through these barriers easily if they really want to.



Conclusions

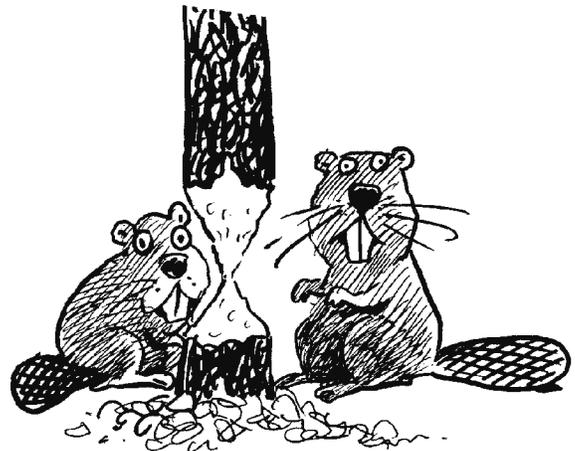
As beaver populations continue to increase, beavers are expanding into new areas and the problems they cause are increasing. The best solution to the problem of beavers damming culverts is to redesign and replace the culverts that beavers have dammed. Oversized culverts help prevent beavers from building dams. The culvert's location is another factor. Replacing culverts is expensive and is not an option in most cases. When replacing culverts is not an option, managers can consider:

- Installing devices that keep beavers from damming culverts. These devices can be grates or rebar installed in the culvert entrance, small wire mesh fences placed in front of the culvert, or wire mesh culvert extensions. Sometimes beaver will leave the area when these devices are installed. In other cases, they will build dams against them. Periodic maintenance can keep the culvert free of material. These techniques, especially the culvert fence, have been used successfully in almost all regions.
- Installing devices that allow water to flow through the culvert. These devices may keep beavers from building dams or they may limit the size of the dams. Many designs exist, but the main idea is to keep water flowing slowly and quietly through the pipe so beavers don't hear the sounds of rushing water that arouse their instincts to build dams. Devices using perforated tubing, the Clemson Beaver Pond Leveler, T-culverts, culvert blocks, and simple log drains can be effective. Routine maintenance is required to keep the systems from being clogged by debris.
- Trapping or shooting. Trapping or shooting can be an effective, relatively low-cost method of reducing beaver problems. Beavers can be trapped and relocated if suitable relocation sites exist. Trapping is prohibited in some States. All programs must be conducted in accordance with applicable regulations. Trapping and shooting may provide no

more than a short-term solution because other beavers probably will show up if the habitat is good. Usually, systematic annual trapping or shooting programs are required.

- Using devices that frighten beavers. These devices attempt to make an area appear threatening. While most methods do not work for more than a few days, an electric fence with dangling loops was effective in one instance.
- Using repellants. Repellants are not effective in reducing culvert problems, but can be used to protect riparian areas. Commercial repellants do not offer much protection to larger trees, but can protect willow or cottonwood seedlings from beavers. Grit added to paint and applied to the base of trees was more effective than standard repellants.
- Installing fences. Fences up to 500 feet long can be placed in an area to effectively exclude beavers. The coated mesh or chain link fence does not need to be more than 2 feet high. The fence must be tight against the ground or buried a few inches to keep beavers from digging or crawling underneath it. This method is fairly expensive, but could be used to protect small areas.

Site conditions, habitat, and beaver populations will play a large role in determining whether any particular method will be successful.





Appendix—The Clemson Beaver Pond Leveler

Wildlife Services in Mississippi conducted a survey to determine whether Clemson Beaver Pond Levelers they had installed were meeting landowners' objectives. Wildlife Services is a program in the U.S. Department of Agriculture Animal and Plant Health Inspection Service. The survey considered:

- Management objectives
- The length of time since the leveler was installed
- Watershed characteristics
- Physical attributes of the stream and the beaver dam
- Beaver activity

Twenty of the forty Clemson Beaver Pond Levelers evaluated were operating and regarded as successful by the landowner. The landowners' original management objectives correlated with the operational status of the device and the owner's satisfaction with it. Devices installed to manage wetlands (primarily waterfowl habitat) generally were considered successful, while devices installed to provide perpetual waterflow were deemed less successful. At least six of the unsuccessful devices had been removed by the landowner, usually because the owner wanted more waterflow.

Most factors considered in the survey were not repeated consistently among sites, confounding comparisons and

making the results more like a series of case studies than a replicated experiment. However, general patterns or trends could be deduced. Successful devices tended to have been installed more recently (21.5 months) than unsuccessful devices (32 months). A few levelers had been installed within the past 6 months. All of those were considered successful. But several devices that had been installed for longer than 48 months were still in good condition.

There was no apparent relationship between the likelihood that a device would be successful and the characteristics of the beaver dam. Watershed characteristics and stream attributes also were unrelated to owner satisfaction, although these attributes often were tied to management objectives. For example, both successful and unsuccessful devices often were located on small drainages with intermittent flow, but the successful and unsuccessful devices were not necessarily installed for the same reason. Devices installed for wildlife management objectives invariably were placed on small drainages with intermittent flow.

Maintenance had been performed on 70 percent of the 20 operating Clemson Beaver Pond Levelers installed by Wildlife Services. Usually, maintenance involved adjusting the riser to manipulate water levels. Owners had adjusted

risers on 11 of the 20 successful devices, while only four attempts were made to adjust risers on the 20 unsuccessful devices. Vegetation was cleared near two of the successful devices and secondary dams were removed near three of the successful devices. The failure of nine devices regarded by landowners as unsuccessful was attributed to secondary dams. It is difficult to assess whether removal of dams, additional devices, population reduction, or a combination of these measures would have improved landowner's perceptions of the device's performance.

Population control measures appeared to increase the success of Clemson Beaver Pond Levelers. Population control measures were practiced on 95 percent of the sites considered successful. The actual density of beavers on these sites before and after control measures is unknown. It is impossible to determine an optimum density of beavers for successful operation of these devices. However, these data suggest that a density threshold probably does exist. When the beaver population exceeds that threshold, a device is less likely to meet a landowner's objectives.

Population control measures alone do not ensure successful operations. Population reduction measures were practiced on 50 percent of the sites where landowners were not satisfied with the results. Perhaps beaver densities remained too high at those sites. Six devices were removed by landowners to

increase waterflow without regard to whether they were plugged.

These findings reflect the recommendations for using the Clemson Beaver Pond Leveler. The Clemson University Cooperative Extension Service says that "the leveler is not a panacea for eliminating all beaver problems" and "the leveler does not negate the need for direct control of beaver populations where problems are both extensive and severe; however, it may reduce this need."

A Massachusetts pamphlet considered the Clemson Beaver Pond Leveler to be:

- "An effective tool in situations where water input to a pond is from a small stream or spring"
- "Suitable only for small watersheds"
- "Susceptible to problems related to the inability of the device to handle large amounts of water during periods of unusually high rainfall"

A Minnesota Department of Natural Resources pamphlet says that the device is an effective tool to resolve problems created when a dam is built at a critical location but not problems caused by beavers elsewhere. This pamphlet recommends that "in most beaver flooding situations, the most effective way to reduce flooding is to remove beaver and then the dam or culvert plug."



Notes



Notes



Notes

About the Authors

Dr. Dale Nolte is the Mammal Research Program Manager for the USDA/APHIS Wildlife Services National Wildlife Research Center. Dr. Nolte has conducted research over the past several years to assess the efficacy of nonlethal devices to deter beaver from building dams or gnawing on trees. He earned a Ph.D. in foraging ecology from Utah State University.

Dr. Dale H. Arner is a retired Professor from Mississippi State University. Dr. Arner is recognized as one of the premier experts on beaver ecology and management, contributing significantly to the literature available on beaver in the south and providing practical strategies to manage beaver. He earned a Ph.D. in Wildlife Management from Auburn University.

John Paulson received his bachelor of science degree in wildlife management from the University of Minnesota. He has worked for the Minnesota Department of Natural

Resources and the U.S. Fish and Wildlife Service while in Minnesota. He spent 6 years with the USDA Animal Damage Control in Mississippi. John is currently the district supervisor for the USDA Wildlife Services in North Dakota.

Dr. Jeanne C. Jones is a Professor at Mississippi State University. Dr. Jones is interested in the impacts beaver have on associated flora and fauna and has led several graduate students in conducting beaver studies in Mississippi. She earned a Ph.D. in wildlife ecology from Mississippi State University.

Andy Trent is a project engineer at MTDC. He received his bachelor's degree in mechanical engineering from Montana State University in 1989. Before coming to MTDC in 1996, he worked as a civilian engineer for the U.S. Navy. Andy works on projects in the nurseries and reforestation, forest health protection, and watershed, soil, and air programs.

Library Card

Nolte, Dale; Arner, Dale H.; Paulson, John; Jones, Jeanne C.; Trent, Andy. 2005. How to keep beavers from plugging culverts. Tech. Rep. 0571-2830-MTDC. Missoula, MT: U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center. 30 p.

Describes ways to address the problems caused by beavers that dam culverts. This problem has become more serious as beaver populations have recovered from unregulated trapping during the 19th century. The rapid flow of water through culverts and noise of running water trigger beavers' instincts to build a dam. If the speed of flow and the noise of running water can be reduced, beavers may leave culverts alone. Often, the best solution is to replace the culvert

with one that is oversized or to move it to a more suitable location. Either choice is expensive. When existing culverts can't be replaced or relocated, options include:

- Installing devices that keep beavers from damming culverts
- Installing waterflow devices that control the speed and noise of the water
- Using devices to frighten the beavers (short-term solution)
- Trapping or shooting the beavers (they could be replaced by others living nearby)
- Fencing the area to keep beavers out

Keywords: animal damage control, dams, fencing, flooding, repellants, Wildlife Services

For additional information about how to keep beavers from plugging culverts, contact Andy Trent at MTDC.

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Electronic copies of MTDC's documents are available on the Internet at: <http://www.fs.fed.us/eng/t-d.php>

Forest Service and Bureau of Land Management employees can search a more complete collection of MTDC's documents, videos, and CDs on their internal computer networks at: <http://fsweb.mtdc.wo.fs.fed.us/search>